CHAPTER

STRUCTURE OF ATOMS

MULTIPLE CHOICE QUESTIONS

1. **Matter is composed of tiny indivisible particles called**
   (a) Element (b) Atom (c) Compound (d) substance
2. **Atom of the same elements are**
   (a) Different (b) Alike (c) Comparable (d) Active
3. **Conduction of electricity in gasses was performed by**
   (a) J.J. Thomson (b) Rutherford (c) Dalton (d) Bohr
4. **The pressure inside the discharge tube for the discovery of electron was kept**
   (a) 10^4 atm (b) 10^{-4} atm (c) 10^{14} atm (d) 10^{-14} atm
5. **He was the pioneer of the vacuum tubes**
   (a) William crook (b) Rutherford (c) Bohr (d) Dalton
6. **The nature of canal rays depends upon**
   (a) Nature of anode (b) Nature of Cathode
   (c) Nature of gas (d) Nature of particles
7. **The mass of proton is more than that of an electrons**
   (a) 1830 time (b) 1840 time (c) 2 time (d) 3 time
8. **By the bombardment of the helium particle on beryllium it is produced**
   (a) Alpha (b) Beta (c) Neutron (d) None of these
9. **They are highly penetrating rays**
   (a) Alpha (b) Beta (c) Neutron (d) None of these
10. **Neutron was discovered by**
    (a) Rutherford (b) Chadwick (c) Bohr (d) William Crook
11. **Rutherford used the foil made up of**
    (a) Silver (b) Tin (c) Platinum (d) Gold
12. **Alpha particles are emitted by radioactive element**
    (a) Carbon (b) Polonium (c) Neon (d) Vanadium

13. **Rutherford used the photographic plate coated with**
    (a) Zinc sulphide (b) Zinc sulphite (c) Zinc oxide (d) Zinc sulphate
14. **Who is the father of nuclear chemistry**
    (a) Rutherford (b) Dalton (c) William Crood (d) Joseph proust
15. **Electrons shows spectrum according to quantum theory**
    (a) Continues (b) Line (c) Circular (d) Color spectrum
16. **Which of the following are fundamental particles of an atom**
    (a) Ion (b) Atom (c) Electron (d) substance
17. **Matter is composed of tiny indivisible particles called as:**
    (a) Electrons (b) Protons (c) Atoms (d) Neutrons
18. **The meaning of Latin word 'atoms' is:**
    (a) Indivisible (b) Divisible (c) Both a & b (d) None of these
19. **Rutherford used a thin sheet of gold of thickness:**
    (a) 0.00004cm (b) 0.004cm (c) 0.0004cm (d) 0.04cm
20. **Each orbit has a fixed amount of energy that is :**
    (a) Quantized (b) Dispersed (c) Both a & b (d) None of these
21. **Protons were discovered by:**
    (a) Thomson (b) Chadwick (c) Moseley (d) Goldstein
22. **Rutherford bombarded a thin sheet of gold with:**
    (a) α-particles (b) β-particles (c) γ-particles (d) x-rays
23. **Which apparatus was used by Sir William Crooks in his experiment?**
    (a) Test tube (b) Discharge tube (c) Zinc plate (d) None of these
24. **Which are three fundamental particles of an atom?**
    (a) Ion, radicals, free radicals (b) Electrons, protons, neutrons
    (c) Electrons, protons, cathode rays (d) Canal rays, x-rays, gamma rays
25. **The electrons revolve around the:**
    (a) atom (b) nucleus (c) Protons (d) None of these
26. **Nature of gas present in discharge tube effects the nature of:**
    (a) canal rays (b) x-rays (c) cathode rays (d) β-rays

Q.5 How can you prove that angular momentum is quantized?

Hint: Le angular momentum (mvr) of 1st orbit is mvr = nh/2π

$$mvr = \frac{6.63\times10^{-34}}{2\times3.14} 1.0\times10^{-34} kgm^2s^{-1}$$

Ans. Angular momentum (mvr) of any orbit is quantized.

Angular momentum of 1st orbit (n=1)

$$mvr = \frac{6.63\times10^{-34}}{2\times3.14} = 1.0\times10^{-34} kgm^2s^{-1}$$

Angular momentum of 2nd orbit (n=2)

$$mvr = \frac{nh}{2\pi}$$

$$mvr = \frac{2\times6.63\times10^{-34}}{2\times3.14} = \frac{13.26\times10^{-34}}{6.28}$$

Result $2.11\times10^{-34} kgm^2s^{-1}$

2.2 ELECTRONIC CONFIGURATION

Q.1 What is the maximum number of electrons that can be accommodated in p-subshell?

Ans. The maximum number of electrons in p-subshell is 6.

Q.2 How many subshells are there in second shell?

Ans. The second energy level or L-shell has two subshells "s" and "p"

Q.3 Why does an electron first fill 2p orbital and then 3s orbital?

Ans. Because 2p subshell is closer to the nucleus having minimum energy and lower energy level is occupied 1st then higher energy level. Because of this 2p subshell filled first then 3s subshell.

Q.4 If both K and L shells of an atom are completely filled; what is the total number of electrons present in them?

Ans. K-shell can accommodate 2 electrons and L-shell can accommodate 8 electrons so total number of electrons in both shell will be 10 electrons.

Q.5 How many electrons can be accommodated in M shell?

Ans. In m-shell total number of electrons can accommodate are 18 having subshell s,p and d.

Q.6 What is the electronic configuration of a hydrogen atom?

Ans. $H_1 = 1s^1$

Q.7 What is atomic number of phosphorus? Write down its electronic configuration.

Ans. Atomic number of phosphorus = $_{15}P$.

$$_{15}P = 1s^2, 2s^2, 2p^6, 3s^2, 3p^3$$

Q.8 If an element has atomic number 13 and atomic mass 27; how many electrons are there in each atom of the element?

Ans. Because total number of electrons and protons are equal to the atomic number so atomic number of element is 13 and having electron 13.

Q.9 How many electrons will be in M shell of an atom having atomic number 15?

Ans. Atomic number = 15

M-shell is the 3rd energy level so it has 5 electrons as its electronic configuration is

K	L	M
2	8	5

Q.10 What is maximum capacity of a shell?

Ans.

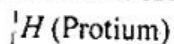
K	L	M	N
2	8	18	32

SHORT QUESTIONS

2.1 THEORIES AN EXPERIMENTS RELATED TO STRUCTURE OF ATOMS

Q.1 Do you know any element having no neutrons in its atoms?

Ans. Hydrogen is that element which do not have neutron in its one of the isotope. That isotope is protium, which is as follows:

$${}^{1}_{1}H \text{ (Protium)}$$

Q.2 Who discovered an electron, a proton and a neutron?

Ans.

- Goldstein discovered protons
- J.J. Thomson discovered electrons.
- Chadwick discovered neutrons.

Q.3 How does electron differ from a neutron?

Ans.

Electron	Neutron
• Electrons are known as cathode rays	• Neutrons are highly penetrating radiations.
• Electrons are negatively charge particles.	• Neutrons are neutral particles having no charge.

Q.4 Explain how anode rays are formed from the gas taken in the discharge tube?

Ans. In discharge tube, there were not only cathode rays were produced, in fact anode rays or canal rays were also present, which travel in a straight line in a direction opposite to cathode rays. Goldstein used a discharge tube which have perforated cathode. He found that these rays passed through holes present in the cathode and produced a glow on the wall. He called these rays as 'canal rays'.

2.1.1 RUTHERFORD'S ATOMIC MODEL AND BOHR'S ATOMIC MODEL

Q.1 How was it proved that the whole mass of an atom is located at its centre?

Ans. Rutherford observed in his experiment that atomic mass of the element could not be explained on the basis of the masses of electron and proton only. He predicted in 1920 that some neutral particle having mass equal is that of proton must be present in an atom. This is proved by Chadwick and proved that the whole mass of an atom is located at its centre.

Q.2 How was it shown that atomic nuclei are positively charged?

Ans. According to the Rutherford's experiment it was observed that the deflection of a few particles proved that there is a 'center of positive charges' in an atom, which is called 'nucleus' of an atom.

Q.3 Name the particles which determine the mass of an atom.

Ans. The particles present in the nucleus are called nucleon which determine the mass of an atom. These particles are protons and neutrons.

Q.4 What is the classical theory of radiation ? How does it differ from quantum theory?

Ans. According to classical theory, electrons being the charged particles should release or emit energy continuously and they should ultimately fall into the nucleus. It differs from quantum theory because quantum means fixed energy. It is the smallest amount of energy that can be emitted or absorbed as electromagnetic radiation.

2.3 ISOTOPES

Q.1 Why do the isotopes of an element have different atomic masses?

Ans. Isotopes of an element have same atomic number but different mass number. Mass number is the sum of protons and neutrons. Isotopes of an element have the same number of protons but different their number of neutron.

Example: Hydrogen has 3 isotopes

$^{1}_{1}H$ $^{2}_{1}H$ $^{3}_{1}H$

Q.2 How many neutrons are present in C-12 and C-13?

Ans. C–12 & C–13

	Atomic No.	Mass No.	No. of proton	No. of neutrons
C-12	6	12	6	6
C-13	6	13	6	7

Q.3 Which of the isotopes of hydrogen contains greater number of neutrons?

Ans. The naturally occurring hydrogen is a combination of its three isotopes.

- Protium $^{1}_{1}H$
- Deutrium $^{2}_{1}H$ or (D)
- Tritium $^{3}_{1}H$ or (T)

Amont these three isotopes of Hydrogen tritium have the 2-neutron while protium have no neutron and Deutrium have 1 number. So trituium contain greater number of neutrons.

Q.4 Give one example each of the use of radioactive isotope in medicine and radiotherapy.

Ans. Radioactive isotpe used in medicine is iodine–131.

Radioactive isotopes used in Radiotherapy

- Cobalt – 60
- Sr. – 90
- Phosphorous – 32

Q.5 How is the goiter in thyroid gland detected?

Ans. Radioactive isotope of iodine – 131 is used for diagnosis of goiter is thyroid gland.

Q.6 Define nuclear fission reaction.

Ans. It is a type of nuclear reaction in which an isotopic element is bombarded with the slow moving neutrons that isotopic element emit three neurons and split into some other isotopic elements.

Example: $^{235}_{92}U + ^{1}_{0}n \longrightarrow ^{139}_{56}Ba + ^{94}_{36}Kr + 3^{1}_{0}n + \text{Energy}$

Q.7 When U-235 breaks up, it produces a large amount of energy. How is this energy used?

Ans. In this reaction a large amount of energy is released which may be used to convert water into steam in boiler, the stream then drives the turbines to generate electricity. In this way the energy is used for peace full development of nation.

$$^{235}_{92}U + ^{1}_{0}n \longrightarrow ^{139}_{56}Ba + ^{94}_{36}Kr + 3^{1}_{0}n + \text{Energy}$$

Q.8 How many neutrons are produced in the fission reaction of U-235?

Ans. During this reaction, three neutrons one are produced.

$$^{235}_{92}U + ^{1}_{0}n \longrightarrow ^{139}_{56}Ba + ^{94}_{36}Kr + 3^{1}_{0}n + \text{Energy}$$

Q.9 U-235 fission produces two atoms of which elements?

Ans. When U-235 is bombarded with slow moving neutrons, the uranium nucleus breaks up to produce Barium – 139 and Krypton – 94 and three neutrons. So, the isotopes of barium and krypton are produced by the fission of U – 235.

$$^{235}_{92}U + ^{1}_{0}n \longrightarrow ^{139}_{56}Ba + ^{94}_{36}Kr + 3^{1}_{0}n + \text{Energy}$$

LONG QUESTIONS

Introduction

Ancient Greek philosopher Democritus suggested that matter is composed of tiny indivisible particles called atoms. The name atom was derived from the Latin word 'Atomos' meaning indivisible. In the beginning of 19th century John Dalton put forward Atomic Theory. According to it 'all matter is made up of very small indivisible particles called atoms'. Till the end of 19th century it was considered that atom cannot be subdivided. However, in the beginning of 20th century experiments performed by Goldstein, J. J. Thomson, Rutherford, Bohr and other scientist revealed that atom is made up of subatomic particles like electron, proton and neutron. Properties of these subatomic particles are discussed in this chapter.

THEORIES AND EXPERIMENTS RELATED TO STRUCTURE OF ATOM

Q. No. 1 What is the Dalton's atomic theory and Plum pudding theory?

Dalton's atomic theory

- An atom is an indivisible, hard, dense sphere.
- Atoms of the same element are alike.
- They combine in different ways to form compounds.

In the light of Dalton's atomic theory, scientists performed a series of experiments. But in the late 1800's and early 1900's, scientists observed new sub-atomic particles.

Plum pudding theory

Thomson put forth his "plum pudding" theory. He postulated that atoms were solid structures of positively charge with tiny negative particles stuck inside. It is like plums in the pudding.

Q. No. 2 How the cathode rays were discovered? Write down its properties.

CATHODE RAYS AND DISCOVERY OF ELECTRON

Introduction

In 1895 Sir William Crooks performed experiments by passing electric current through gases in a discharge tube at very low pressure.

Experiment

He took a glass tube fitted with two metallic electrode, which were connected to a high voltage battery. The pressure inside the tube was kept 10-4 atm. When high voltage current was passed through the gas, shiny rays were emitted from the cathode towards the anode as shown in figure 2.1. These rays were given the name of 'cathode rays' as these were originated from the cathode.

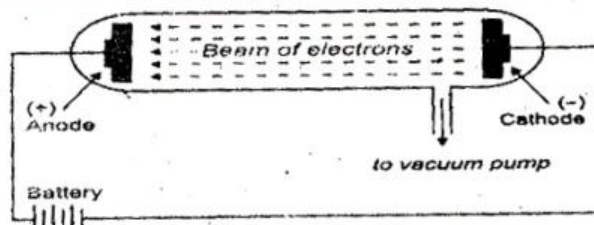



Fig 2.1 Discharge tube used for the production of cathode rays.

Properties

- These rays travel in a straight line perpendicular to the cathode surface.
- They can cast a sharp shadow of an opaque object if placed in their path.
- They are deflected towards positive plate in an electric field showing that they are negatively charged.
- They raise temperature of the body on which they fall.
- J.J. Thomson discovered their charge/mass (e / m) 'ratio:
- Light is produc~d when these rays hit the sides of the discharge tube.
- It was found that the same type of rays were emitted no matter which gas and which cathode was used in the discharge tube.

Conclusion

All these properties suggested that the nature of cathode rays was independent of the nature of the gas present in the discharge tube or material of the cathode. The fact that they cast the shadow of an opaque object suggested that these are not rays but they are fast moving material particles. They were given the name electrons.

Interpretation

Since all the materials produce same type of particles, it means all the materials contain electrons. As we know materials are composed of atoms, hence the electrons are fundamental particles of atoms.

Q. No. 3 How the protons were discovered? Write down its properties.

DISCOVERY OF PROTON

Introduction

In 1886 Goldstein observed that in addition to cathode rays, other rays were also present in the discharge tube.

Experiment

These rays were traveling in opposite direction to cathode rays. He used a discharge tube having perforated cathode as shown in figure 2.2. He found that these rays passed through holes present in the cathode and produced a glow on the wall. He called these rays as "canal rays".

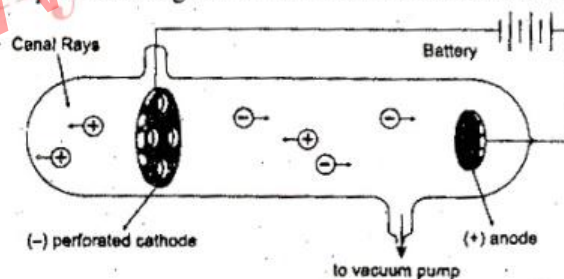



Fig 2.2 Discharge tube used for the production of canal rays.

Properties

- These rays travel in a straight line in a direction opposite to cathode rays.
- Their deflection in electric and magnetic field proved that these were positively charged.
- The nature of canal rays depends upon the nature of gas, present in the discharge tube.
- These rays do not originate from the anode. In fact these rays are produced when the cathode rays or electrons collide with the residual gas molecule present in the discharge tube and ionize them.
- Mass of these particles was found equal to that of a proton or simple multiple of it. The mass of a proton is 1840 times more than that of an electron.

Conclusion

Thus, these rays are made up of positively charged particles. The mass and charge of theseparticles depend upon the nature of the gas in the discharge tube. Hence, different gases produce different types of positive rays having particles of different masses and different charges. Keep in mind that positive particles produced by a gas will be of the same type i.e. positive rays produced by the lightest gas hydrogen contain protons.

Q. No. 4 How the neutrons were discovered? Write down its properties.

DISCOVERY OF NEUTRON

Introduction

Rutherford observed that atomic mass of the element could not be explained on the basis of the masses of electron and proton only. He predicted in 1920 that some neutral particle having mass equal to that of proton must be present in an atom. Thus scientists were in search of such a neutral particle.

Experiment

In 1932 Chadwick discovered neutron, when he bombarded alpha particles on a beryllium target. He observed that highly penetrating radiations were produced. These radiations were called neutron.

Properties

- Neutrons carry no charge i.e. they are neutral
- They are highly penetrating.
- Mass of these particles was nearly equal to the mass of a proton.

Q. No. 5 Explain the Rutherford's atomic model.

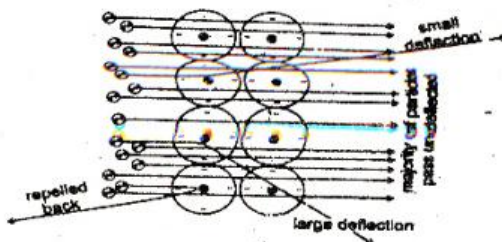
2.1.1 RUTHERFORD'S ATOMIC MODEL

Introduction

Rutherford performed 'Gold Foil' experiment to understand how negative and positive charges could coexist in an atom.

Experiment

He bombarded alpha particles on a 0.00004 cm thick gold foil. Alpha particles are emitted by radioactive elements like radium and polonium: These are actually helium nuclei (He^{2+}). They can penetrate through matter to some extent.

He observed the effects of a-particles on a photographic plate or a screen coated with zinc sulphide He proved that the 'plum-pudding' model of the atom was not correct.

Scattering of alpha particles by the atoms of gold foil

Observations

- Almost all the particles passed through the foil un-deflected.
- Out of 20000 particles, only a few were deflected at fairly large angles and very few bounced back on hitting the gold foil.

Results

Rutherford proposed planetary model for an atom and concluded following results:

- Since most of the particles passed through the foil un-deflected, therefore most of the volume occupied by an atom is empty.
- The deflection of a few particles proved that there is a 'center of positive charges' in an atom, which is called 'nucleus' of an atom.
- The complete rebounce of a few particles show that the nucleus is very dense and hard.
- Since a few particles were deflected it shows that the size of the nucleus is very small as compared to the volume of an atom.
- The electrons revolve around the nucleus.
- An atom as a whole is neutral, therefore the number of electrons in an atom is equal to the number of protons.
- Except electrons, all other fundamental particles that lie within a nucleus are known as nucleons.

Defects in Rutherford's Model

- According to classical theory, electrons being the charged particles should release or emit energy continuously and they should ultimately fall into the nucleus.
- If the electrons emit energy continuously, they should form a continuous spectrum but in fact, line spectrum was observed.

Q. No. 6 Write down the postulates of Bohr's atomic theory.

2.1.2 BOHR'S ATOMIC THEORY

Introduction

Neil Bohr presented another model of atom in 1913 in result of the defects in Rutherford's Atomic Model

Basis of Bohr's Atomic Theory

The Quantum Theory of Max Planck was used as foundation for this model.

Energy Level

Bohr's model revolving electron in an atom does not absorb or emit energy continuously. The energy of a revolving electron is 'quantized' as it revolves only in orbits of fixed energy, called 'energy levels' by him.

Postulates

- The hydrogen atom consists of a tiny nucleus and electrons are revolving in one of circular orbits of radius or' around the nucleus.
- Each orbit has a fixed energy that is quantized.
- As long as electron remains in a particular orbit it does not radiate or absorb energy. The energy is emitted or absorbed only when an electron jumps from one orbit to another.
- When an electron jumps from lower orbit to higher orbit it absorbs energy and when it jumps back from higher orbit to lower orbit it radiates energy.

  This change in energy, ΔE is given by following Planck's equation

$$\Delta E = E_2 - E_1 = h\upsilon$$

Where, h is Planck's constant equal to 6.63 x 10-34 J s, and v is frequency of light.

Fig 2.4 Bohr's atomic model showing orbits.

- Electron can revolve only in orbits of a fixed angular moment mvr, given as:

$$mvr = nh/2\pi r$$

Where on' is the quantum number or orbit number having values 1,2,3 so on.

Q. No. 7 What is difference between Rutherford's Atomic theory and Bohr's Atomic theory.

SUMMARY OF DIFFERENCES BETWEEN TWO THEORIES:

	Rutherford's Atomic Theory	Bohr's Atomic Theory
i.	It was based on classical theory.	It was based upon quantum theory.
ii.	Electrons revolve around the nucleus.	Electrons revolve around the nucleus in orbits of fixed energy.
iii.	No idea about orbits was introduced.	Orbits had angular momentum.
iv.	Atoms should produce continuous spectrum.	Atoms should produce line spectrum.
v.	Atoms should collapse.	Atoms should exist.

2.2 ELECTRONIC CONFIGURATION

Q. No. 8 What is shell? Write down its properties.

Shell

Electrons in an atom revolve around the nucleus in a certain definite path is called shell.

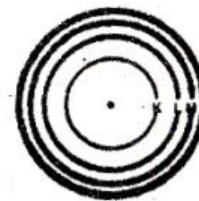
Properties

- Shells are the main energy levels that electrons occupy.
- Shells are represented by circles around the nucleus.
- The number of electron that a shell can accommodate is given by $2n^2$, where 'n' is the shell number.
- Different energy levels or shells are counted from the centre to outwards.
- A shell also consists of subshells or orbitals.
- Each subshell or orbital is designated by a small alphabetical letter s, p, d etc.
- Energy levels are represented by on' values 1,2,3 and so on.
- Shells are designated by the alphabets or shells K, L, M and so on.
- A shell closer to the nucleus is of minimum energy.
- Since K shell is closest to the nucleus, the energy of shells increases from K shell and onwards.

Energy level

1^{st} energy level is K shell; it has the lowest energy.
2^{nd} energy level is L shell; it has more energy than K shell.
3^{rd} energy level is M shell; it has more energy than K and L shell.
4^{th} energy level is N shell; it has more energy than K, L and M shell

The maximum capacity of shells to accommodate

K shell can accommodate 2 electrons
L shell can accommodate 8 electrons
M shell can accommodate 18 electrons.
N shell can accommodate 32 electrons.

Q. No. 9 What is sub-shell? Write down its properties.

Sub-shell

Each shell is composed of one or more sub shells which are composed of orbitals is called sub shell.

Properties

- First energy level or K shell has only one subshell called s subshell.
- Second energy level L, shell has two subshells sand p.
- Third energy level M shell has three subshells s, p and d.
- Fourth energy level or N shell has four subshells s, p, d and f.

2.2.1 ELECTRONIC CONFIGURATION OF FIRST 18 ELEMENTS

Q. No. 10 Explain electronic configuration and give the rules for electronic configuration.

Definition

The distribution of electrons around the nucleus in various shells and subshells according to their increasing energy is called electronic configuration.

Explanation

The most stable or ground state electronic configuration of an atom is the one in which electrons are present in the lowest possible energy level. The electrons fill the shells in order of their increasing energy, i.e. lower energy level is occupied first then the higher energy level and so on as indicated earlier.As we know there is a slight difference between the energies of the sub shells or orbital within a shell, therefore, filling of electrons in sub shells of a shell is such as that's' sub shell is filled first and then its p sub shell and then other sub shells are filled.

The maximum capacity of sub shells to accommodate electrons

's' orbital can accommodate 2 electrons.
'p' orbital can accommodate 6 electrons.
'd' orbital can accommodate 10 electrons.
'f' orbital can accommodate 14 electrons.

Rules for electronic configuration

- The number of electrons in an atom.
- The sequence of shells and subshells according to the energy level.
- The maximum number of electrons that can be placed in different shells and sub shells.

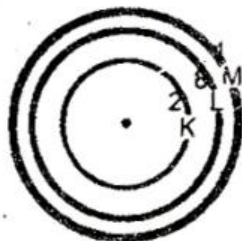
Example 2.1

Write the electronic configuration of an element having 11 electrons.

Solution

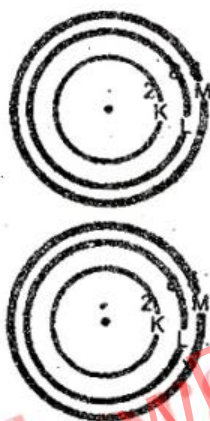
Keep in mind that all the electrons do not have the same energy. Therefore, they are accommodated in shells according to increasing energy and capacity of the shell. First of all, the electrons will go to K shell which has minimum energy. It can accommodate 2 electrons. After this, electrons will go to L shell that can accommodate 8 electrons. Thus K and L shells have accommodated 10 electrons. The remaining 1 electron will go to M shell, the outermost shell of maximum energy in this case. The electronic configuration will be written as: K L M

K L M
2, 8, 1

But it is not necessary to write the subshells. Therefore, it is simply written as 2,8, and 1. Further distribution of electrons in subshells will be: $1s^2, 2s^2, 2p^6, 3s^1$.

Example 2.2

Write down the electronic configuration of Cl- ion

Solution

We know that chlorine has 17 electrons and chloride ion (Cl^-) has 17 + 1 = 18 electrons. Its electronic configuration will be 2, 8, 8, which is presented in the figure. The further distribution of electrons in subshells will be $1s^2, 2s^2, 2p^6, 3s^2. 3p^6$.

Example 2.3

An element has 5 electrons in M shell. Find out its atomic number.

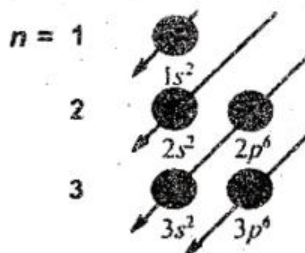
Solution:

When there are 5 electrons in M shell, it means K and L shell are completely filled with their maximum capacity of 10 electrons. Hence the electronic configuration of the element is:

K L M
2, 8, 5

So, the total number of electrons is 2 + 8 + 5 = 15

The number of electrons in an atom is equal to its atomic number.

Therefore, atomic number of this element is 15.

2.2.2 THE ELECTRONIC CONFIGURATION OF FIRST 18 ELEMENT

The sequence of filling of electrons in different sub shells is as following:

$1s^2$, 2s2, $2p^2$, $3s^2$, $2p^6$..............

Where number represents the shell number, while letters (s and p) represent sub shells. Superscript shows the number of electrons in a sub shell. The sum of superscripts number is the total number of electrons in an atom. i.e. atomic number of an element.

THE ELECTRONIC CONFIGURATION OF LIST 18 ELEMENTS

Element	Symbol	Atomic Number	Electronic Configuration
Hydrogen	H	1	$1s^1$
Helium	He	2	$1s^2$
Lithium	Li	3	$1s^2, 2s^1$
Beryllium	Be	4	$1s^2, 2s^2$
Boron	B	5	$1s^2, 2s^2, 2p^1$
Carbon	C	6	$1s^2, 2s^2, 2p^2$
Nitrogen	N	7	$1s^2, 2s^2, 2p^3$
Oxygen	O	8	$1s^2, 2s^2, 2p^4$
Fluorine	F	9	$1s^2, 2s^2, 2p^5$
Neon	Ne	10	$1s^2, 2s^2, 2p^6$
Sodium	Na	11	$1s^2, 2s^2, 2p^6, 3s^1$
Magnesium	Mg	12	$1s^2, 2s^2, 2p^6, 3s^2$
Aluminium	Al	13	$1s^2, 2s^2, 2p^6, 3p^1$
Silicon	Si	14	$1s^2, 2s^2, 2p^6, 3p^2$
Phosphorus	P	15	$1s^2, 2s^2, 2p^6, 3p^3$
Sulphur	S	16	$1s^2, 2s^2, 2p^6, 3p^4$
Chlorine	Cl	17	$1s^2, 2s^2, 2p^6, 3p^5$
Argon	Ar	18	$1s^2, 2s^2, 2p^6, 3p^6$

Q. No. 11 Explain the isotopes with the help of example.

2.3 ISOTOPES

Definition

The atoms of an element that have same atomic number but different mass numbers.

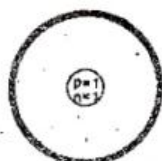
Properties

- They have same electronic configuration and number of protons
- They differ in the number of neutrons.
- Isotopes have similar chemical properties because these depend upon electronic configuration.
- They have different physical properties because these depend upon atomic masses.
- Most of the elements show isotopes.

EXAMPLE

Isotopes of Hydrogen

The naturally occurring hydrogen is combination of its three isotopes, present in different abundances. The three isotopes of hydrogen are named as protium (H), deuterium (H, or D) and tritium (H or T). Each one of them has 1 proton and 1 electron, but number of neutrons are different

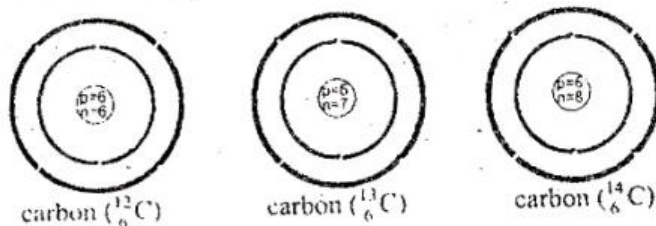
The isotopes are represented as

protium (^1_1H) deuterium (^2_1H) tritium (^3_1H)

Isotopes of Carbon

There are two stable isotopes of carbon 12C and 13C and one radioactive isotope 14c. The isotope 12C is present in abundance of 98.9 %,while 13C and 14C are both present only 1.1 % in nature. All of them have the same number of protons and electrons but differ in number of neutrons. They are represented as follows:

carbon ($^{12}_{6}C$)

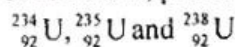
carbon ($^{13}_{6}C$)

carbon ($^{14}_{6}C$)

Isotopes of Chlorine

There are two isotopes of chlorine $^{35}_{17}Cl$ and $^{37}_{17}Cl$.

Isotopes of Uranium

The difference in their number of electrons, protons and neutrons is shown below:

$^{234}_{92}U$, $^{235}_{92}U$ and $^{238}_{92}U$

ATOMIC NUMBER, MASS NUMBER, NUMBER OF PROTONS AND NEUTRONS OF H, C, CI AND U

Symbol	Atomic Number	Mass Number	No. of Proton	No. of Neutron
$_1H$	1	1	1	0
$_2H$	1	2	1	1
$_3H$	1	3	1	2
$_{12}C$	6	12	6	6
$_{13}C$	6	13	6	7
$_{14}C$	6	14	6	8
$_{35}Cl$	17	35	17	18
$_{37}Cl$	17	37	17	20
$2_{34}U$	92	234	92	142
$_{235}U$	92	235	92	143
$_{238}U$	92	238	92	146

Q. No. 12 Write down the application of Radioactive isotopes.

USES / APPLICATION

(i) Radiotherapy (Treatment of Cancer)

- For the treatment of skin cancer, isotopes like P-32 and Sr-90 are used because they emit less penetrating beta radiations.
- For cancer, Co-60, affecting within the body, is used because it emits strongly penetrating gamma rays.

(ii) Tracer for Diagnosis and Medicine

- The radioactive isotopes are used as tracers in medicine to diagnose the presence of tumor in the human body.
- Isotopes of Iodine-131 are used for diagnosis of goiter in thyroid gland.
- Similarly technetium is used to monitor the bone growth.

(iii) Archaeological and Geological Uses

- The radioactive isotopes are used to estimate the age of fossils like dead plants and animals and stones etc.
- The age determination of very old objects based on the half-lives of the radioactive isotope is called radioactive-isotope dating.
- An important method of age determination of old carbon containing objects (fossils) by measuring the radioactivity of C-14 in them is called **radio-carbon dating** or **simply carbon dating.**

(iv) Chemical Reaction and Structure Determination

- The radioisotopes are used in a chemical reaction to follow a radioactive element during the reaction and ultimately to determine the structure.
- For example: C-14 is used to label CO_2. As CO_2 is used by the plants for photosynthesis to form glucose, its movement is detected through the various intermediate steps up to glucose.

(v) Applications in Power Generation

- Radioactive isotopes are used to generate electricity by carrying out controlled nuclear fission reactions in nuclear reactors.
- For example, when U-235 is bombarded with slow moving neutrons, the uranium nucleus breaks up to produce Barium-139 and Krypton and three neutrons.
- A large amount of energy is released which is used to convert water into steam in boilers. The steam then drives the turbines to generate electricity. This is the peaceful use of atomic energy for development of a nation.

TESTING PREVAILING THEORIES BRINGS ABOUT CHANGE IN THEM

Science is a process for producing knowledge. The process depends both on making careful observations of phenomena and inventing theories for making sense out of those observations. Change in knowledge is inevitable because new observations may challenge prevailing theories. No matter how well one theory explains a set of observations, it is possible that another theory may fit just as well or better, or may fit a still wider range of observations. In science, the testing and improving and occasional discarding of theories, whether new or old, go on all the time. Scientists assume that even if there is no way to secure complete and absolute truth, increasingly accurate approximations can be made to account for the world and how it works.

EXERCISE

MCQ'S

1. **Which one of the following results in the discovery of proton**
   (a) cathode rays (b) canal rays (c) x-rays (d) alpha rays.
2. **Which one of the following is the most penetrating.**
   (a) protons (b) electrons. (c) neutrons (d) alpha parti les
3. **The concept of orbit was used by**
   (a) J. J. Thomson (b) Rutherford (c) Bohr (d) Planck
4. **Which one of the following shell consists of three subshells.**
   (a) shell (b) N shell (c) L shell (d) M shell
5. **Which radioisotope is used for the diagnosis of tumor in the body?**
   (a) cobalt-60 (b) iodine-131 (c) strontium-90 (d) phosphorus-30
6. **When U-235 breaks up, it produces:**
   (a) electrons (b) neutrons (c) protons (d) nothing
7. **The p subshell has:**
   (a) one orbital (b) two orbitals (c) three orbitals (d) four orbitals
8. **Deuterium is used to make:**
   (a) light water (b) heavy water (c) soft water (d) hard water
9. **The isotope C-12 is present in abundance of:**
   (a) 96.9 % (b) 97.6 % (c) 99.7 % (d) none of these
10. **Who discovered the proton:**
    (a) Goldstein (b) J. 1. Thomson (c) Neil Bohr (d) Rutherford

ANSWR KEY

1	b	3	c	5	a	7	c	9	d
2	c	4	d	6	b	8	b	10	a

SHORT QUESTIONS

Q.1 What is the nature of charge on cathode rays?

Ans: The properties of cathode rays shows that the nature of cathode rays was independent of the nature of the gas present in the discharge tube or material of the cathode. The fact that they cast the shadow of an opaque object suggested that these are not rays but they are fast moving material particles.

Q.2 Give five characteristics of cathode rays.

Ans: The characteristics of cathode rays are as under:

- These rays travel in a straight line perpendicular to the cathode surface.
- They raise the temperature of the body on which they fall.
- Light is produced when these rays hit the sides of discharge tube.
- They can cast a sharp shadow.
- The nature of rays does not depend upon the nature of as used in discharge tube.

Q.3 The atomic symbol of a phosphorus ion is given as $\left({}^{31}_{15}P^{3-}\right)$

(a) How many protons, electrons and neutrons are there in the ion?
(b) What is name of the ion?
(c) Draw the electronic configuration of the ion.
(d) Name the noble gas which has the same electronic configuration as the phosphorus ion has.

Ans:

- In $[{}^{31}_{15}p^{3-}]$ ion:
- The number of protons = 15
- The number of electron = 18
- The number of neutrons = 16

(b) The name of the ion is.

- P^{-3} is called phosphoides ion.

(c) The electronic configuration of the ion. Phosphorus ion has 15 electron, so its electronic configuration is,

$${}^{31}_{15}P^{-3} = 1s^2, 2s^2, 2p^6, 3s^2, 3p^3$$

(d) Name the noble gas which has the same electronic configuration as the phosphorus ion has?
Phosphorus ion $[P^{3-}]$ 18 is formed by gaining three electrons in its outermost shell. Now, it has same electronic configuration as that of noble gas element "Argon" [Ar] 18.

Q.4 Differentiate between shell and subshell with examples of each.

Ans:

Shell	Sub-shell
• The fixed circular orbits which is associated with a definite amount of energy is called a shell or energy level.	• Each shell composed of one or more subshells. OR The sub division of a shell in an atom is called subshell.
• The shells are subdivided into subshells.	• The subshells are also themselves composed of atomic orbital.
• Example: K, L, M, N etc. are considered as the shells or energy levels of any atom.	• Example: s, p, d and f are considered as the subshells of a shell.

Q.5 An element has an atomic number 17. How many electrons are present in K, L and M shells of the atom?

Ans: Atomic number of an atom is considered as the "Total number proton present in the nucleus of the atom."

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[Cl] = $1s^2, 2s^2, 2p^6, 3s^2, 3p^5$

K = 2-electrons

L = 8-elctrons

M = 7-electrons

Q.6 Write down the electronic configuration of Al^{3+}. How many electrons are present in its outermost shell?

Ans: In case of simple [Al] atom. Its electronic configuration is:

$_{13}Al = 1s^2, 2s^2, 2p^6, 3s^2, 3p^1$

In this case, the outermost shell is "M" and it has three electrons in it.

While in case of [Al^{3+}] ion, It has 10 electrons, so it electronic configuration is

[Al^{3+}] = $1s^2, 2s^2, 2p^6$

Now, the outermost shell is "L" and it has 8 electrons in it.

Q.7 Magnesium has electronic configuration 2, 8, 2,

(a) How many electrons are in the outermost shell?

(b) In which subshell of the outermost shell electrons are present?

(c) Why magnesium tend to lose electrons?

Ans:

(a) The atomic number of "Mg" is 12

[Mg] = $1s^2, 2s^2, 2p^6, 3s^2$

The outermost shell is "M" and it has only two electrons in it.

(b) The outermost electrons of "Mg" are present in "s" subshell of the 3rd shell "M".

(c) Magnesium is a electropositive metal. It can easily lose its two outermost sehll and get charge (2+).

Q.8 What will be the nature of charge on an atom when it loses an electron or when it gains an electron?

Ans: When an atom losses its electron, it becomes positively charged ion called cation. e.g., Metals of 1st, 2nd group when atom gains electrons it becomes negatively charged ion called anion. e.g., Halogens

Q.9 For what purpose is U-235 used?

Ans: A U-235 is used to get large amount of energy which can be used to drives the turbines to generate electricity. This is the peaceful use of atomic energy for the development of a nation.

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Ans: Isotopes of iodine-131 are used for diagnosis if goiter in thyroid gland. These radioactive isotopes are used as tracers in medicine to diagnose the presence of tumor in the human body.

Q.11 Give three properties of positive rays.

Ans: Positive rays are also called "canal rays". Its properties are:

- These rays travel in straight line in a direction opposite to the cathode rays.
- These are positively charged rays.
- Mass of these particles was found equal to that of a proton or simple multiple of it.

Q.12 What are the defects of Rutherford's atomic model?

Ans: The defects are as follows:

- According to this atomic model, a revolving electron being a charged particle must radiate energy continuously. By decreasing energy, it will closer to nucleus but it is known fact that the revolving electron never falls into the nucleus. Thus Rutherford's picture of an atom is faulty.
- Rutherford's model of atom also suggests that there would be a continuous atomic spectrum but actually a line atomic spectrum is obtained.

Q.13 As long as electron remains in an orbit, it does not emit or absorb energy. When does it emit or absorb energy?

Ans: Electrons do not emit or absorb energy till they remains in their orbits. When an electron jumps from high energy level to the lower energy level, it emits energy.

$E_2 - E_1$ = Energy emits and when an electron jumps from lower energy level to high energy level it gains energy.

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LONG QUESTIONS

Q.1 How are cathode rays produced? What are its five major characteristics?

Ans: See the topic discovery of cathode rays and its characteristics

Q.2 How was it proved that electrons are fundamental particles of an atom?

Ans: See the topic characteristics of cathode rays.

Q.3 Draw a labeled diagram to show the presence of protons in the discharge tube and explain how canal rays were produced.

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Q.4 How Rutherford discovered that atom has a nucleus located at the centre of the atom?

Ans: See the topic Rutherford atomic model.

Q.5 One of the postulates of Bohr's atomic model is that angular momentum of a moving electron is quantized. Explain its meaning and calculate the angular momentum of third orbit (i.e. n=3)

Ans: See the topic Bohr's Atomic model.

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Ans: See the topic electronic configuration.

Q.8 Describe the electronic configuration of Na^{+}, Mg^{2+} and Al^{3+} ions. Do they have the same number of electrons in the outermost shell?

Ans: See the topic electronic configuration.

Q.9 Give the applications of isotopes in the field of radiotherapy and medicines.

Ans: See the topic Application of isotopes.

Q.10 What is an isotope? Describe the isotopes of hydrogen with diagrams.

Ans: See the topic Isotopes.

2.3 ISOTOPES

Q.1 Why do the isotopes of an element have different atomic masses?

Ans. Isotopes of an element have same atomic number but different mass number. Mass number is the sum of protons and neutrons. Isotopes of an element have the same number of protons but different their number of neutron.

Example: Hydrogen has 3 isotopes

$^{1}_{1}H$ $^{2}_{1}H$ $^{3}_{1}H$

Q.2 How many neutrons are present in C-12 and C-13?

Ans. C–12 & C–13

	Atomic No.	Mass No.	No. of proton	No. of neutrons
C-12	6	12	6	6
C-13	6	13	6	7

Q.3 Which of the isotopes of hydrogen contains greater number of neutrons?

Ans. The naturally occurring hydrogen is a combination of its three isotopes.

- Protium $^{1}_{1}H$
- Deutrium $^{2}_{1}H$ or (D)
- Tritium $^{3}_{1}H$ or (T)

Amont these three isotopes of Hydrogen tritium have the 2-neutron while protium have no neutron and Deutrium have 1 number. So trituium contain greater number of neutrons.

Q.4 Give one example each of the use of radioactive isotope in medicine and radiotherapy.

Ans. Radioactive isotpe used in medicine is iodine–131.

Radioactive isotopes used in Radiotherapy

- Cobalt – 60
- Sr. – 90
- Phosphorous – 32

Q.5 How is the goiter in thyroid gland detected?

Ans. Radioactive isotope of iodine – 131 is used for diagnosis of goiter is thyroid gland.

Q.6 Define nuclear fission reaction.

Ans. It is a type of nuclear reaction in which an isotopic element is bombarded with the slow moving neutrons that isotopic element emit three neurons and split into some other isotopic elements.

Example: $^{235}_{92}U + ^{1}_{0}n \longrightarrow ^{139}_{56}Ba + ^{94}_{36}Kr + 3^{1}_{0}n + Energy$

Q.7 When U-235 breaks up, it produces a large amount of energy. How is this energy used?

Ans. In this reaction a large amount of energy is released which may be used to convert water into steam in boiler, the stream then drives the turbines to generate electricity. In this way the energy is used for peace full development of nation.

$$^{235}_{92}U + ^{1}_{0}n \longrightarrow ^{139}_{56}Ba + ^{94}_{36}Kr + 3^{1}_{0}n + Energy$$

Q.8 How many neutrons are produced in the fission reaction of U-235?

Ans. During this reaction, three neutrons one are produced.

$$^{235}_{92}U + ^{1}_{0}n \longrightarrow ^{139}_{56}Ba + ^{94}_{36}Kr + 3^{1}_{0}n + Energy$$

Q.9 U-235 fission produces two atoms of which elements?

Ans. When U-235 is bombarded with slow moving neutrons, the uranium nucleus breaks up to produce Barium – 139 and Krypton – 94 and three neutrons. So, the isotopes of barium and krypton are produced by the fission of U – 235.

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